Applied Mathematics & Engineering Numericals (AMEN)

1 Antragsteller/in

Lehrstuhl Chemische Verfahrenstechnik
M.Sc. Anoj Winston Gladius, Prof. Dr.-Ing. David W. Agar

2 Kurzbeschreibung des Projektes

This project aims to provide our students with the necessary tools to solve every day scientific and engineering problems using numerical simulations in MATLAB. The course assumes students to have had just a basic introduction to MATLAB and is intended to help them understand the techniques for formulating and solving systems of equations and to familiarise them with the powerful tools available to solve most kinds of problems they will encounter in chemical engineering. The course envisaged will encompass eight combined theory and tutorial sessions of 2 hours each and one final assignment.

3 Details zum Projekt

3.1 Istzustand vor Beantragung

MATLAB (matrix laboratory) is a numerical computing environment, which employs a proprietary programming language developed by MathWorks. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, the creation of user interfaces, and interfacing with programs written in other languages, including C, C++, C#, Java, Fortran and Python.

Every chair in BCI has MATLAB licenses and almost every student will encounter this software at some stage in their studies or professional life. This is why the course “Einführung in die Programmierung” is already offered to Bachelor students. While this course covers all the mechanics required for a student to operate MATLAB, the proposed course is about actually using the basics learned and applying them to solve even demanding problems. Elective courses offered by the Mathematics faculty focus on numerical mathematics and numerical solutions to differential equations, but fail to equip the students with the programming skills needed for implementing the algorithms.

The planned course is meant to serve a bridge to close the gap between the two above-mentioned courses and the core engineering courses, at the Bachelor level, for which such tools are essential. Experience has shown that many students lack the familiarity with MATLAB that would enable them to apply it to even the simplest numerical assignments and have to resort to an unsatisfactory and often unsuccessful ‘Learning by doing’. Master students could also attend the course as a refresher class to overcome any deficits they might otherwise encounter. Although a minority of the students will only have contact with the software as users of existing programmes, most may well have to create a new module or modify an existing one as a part of their Bachelor/Master thesis. In order to save time for both the students and the supervising research assistants, it would seem more logical and efficient to offer the necessary training to the students in class rather than providing personal tuition to each of them individually.

It has often been observed that students have problems in grasping concepts presented in lectures in courses such as “Reaktiontechnik 1”, ”Reaktiontechnik 2”, “Introduction to process balancing” and “Reaction Engineering”, where these numerical methods are necessary prerequisites. Such problems faced by the students slow down the lectures and mean that important lecture content must be omitted as a consequence. The proposed course would be arranged to complement the core course material taught at the chair together with further items to help solve a variety of chemical engineering problems in other areas.

3.2 Projektziel/Projektbeschreibung

The main objective of this project is to provide the students with enough theoretical and practical background so that they are confident enough to solve most of the usual engineering problems numerically, or at the least have the toolkit required to proceed and figure out the solutions on their own. The assignment problems would comprise a single big problem composed of various sub-tasks, in which the students would be exposed to all the elements learnt in the course in depth, and assessed accordingly.

This course also aims to teach the students to solve problems in general rather than emphasising individual problems and the theory behind them. It is intended to give students an overview of all the methods and algorithms at such a level, that they can be comprehended even for complex simulations, and to enable them to understand and debug problems that they might encounter later in their professional lives. This course would also help students get a broader mathematical perspective with respect to other important courses taught in the department, closing the gap between the mathematics they learn and its application in the subsequent engineering syllabus and would help them insofar as they could then focus more on the scientific concepts behind the courses rather than trying to cope with both the scientific and mathematical rigour necessary to compete in these classes successfully.

This course will consist of eight classes (1 hour of analytical problem solving + 1 hour of numerical coding), conducted by a research assistant from the CVT chair during the first 3 years. For these classes, slides and problems will be prepared to cover a wide range of topics. Some of the examples are listed below:

- Different coordinate systems, Basic Linear Algebra, Vector and Matrix manipulations, Gradients, Divergence and Laplacian operators and their respective applications
- Linear and Non-Linear equations and solutions using solvers (Matrix inversions and Iterative)
- Solutions to linear ODEs and coupled ODE systems
- PDEs - spatial discretisation and solutions using inbuilt solvers as well as Collocation
- Setting up equation systems from the general balance equation
- Examples include simple physical/chemical problems, transport phenomenon, plant simulations, etc.

3.3 Geplante Laufzeit

It is planned that the course commences in the winter semester of 2019. The course will be held once a year and the proposed structure is shown below:

- 4 weeks: 2 Lectures of 120 Minutes each
- 4 weeks: Time to solve and submit the assignments
- 2 weeks: Correction and grading the assignments

3.4 Indikatoren zur Evaluation des Projektes

Primarily, the number of course participants would serve as an indicator reflecting the interest of students in such a class.

The number of assignments submitted as well as the scores they obtain in the assignment would furnish further evidence on the quality of the tuition.

Evaluations could be distributed to students to assess whether this course assists them in understanding the material taught in other major courses better and to check if this course helps them save valuable time during their Bachelor/Master thesis.

3.5 Nachhaltigkeit/Verstetigung

During the first year, the CVT chair will prepare slides and prepare example exercises for the 8 lectures and the assignment. These materials will be available for subsequent years. The remaining task would be to deliver the lectures, formulate, correct and grade the assignments.
The CVT chair commits itself to carry out all these tasks for the first 3 years after which a long-term solution must be sought. The teaching materials and experience then available would facilitate the perpetuation of the course under new management if so desired.